wise from each other on said wing panel, specified by said digital wing product definition against said wing skin with said critical features in said spars and said wing skin positioned in said predetermined relation to each other; and

probing reference surfaces on said wing panel after positioning said wing panel on said fixture with a coordinate measuring system to obtain accurate position data for said wing panel on said fixture; and

normalizing said wing part program to coincide with said accurate position of said wing panel on said fixture.

fastening said wing spars in fixed relation relative to said wing skin in said predetermined position.

69. A method of manufacturing a wing as defined in claim 68, further comprising:

placing rib-to-spar critical coordination features in a plurality of wing ribs and in said spars using numerically controlled machine tools running on programs incorporating digital wing product definition from an engineering data authority, said ribs being accurately located in a predetermined position specified by said digital wing product definition relative to said wing spars when said rib-to-spar critical features in said ribs and said wing spars are positioned in a predetermined relation to each other; and

fastening said wing ribs to said wing spars in said predetermined position.

70. A method of manufacturing a wing as defined in claim 69, further comprising:

drilling a plurality of stringer-to-chord coordination holes in lower wing skin stringers attached to a lower wing skin and in a lower spar chord using a numerically controlled machine tool running on a program incorporating said digital wing product definition data from said engineering data authority, said lower wing skin being accurately located in a predetermined position specified by said digital wing product definition relative to said wing spars when said stringer-to-chord critical features in said ribs and said wing spars are positioned in a predetermined relation to each other; and

fastening said wing stringers and said wing spars together in said predetermined position.

71. A method of manufacturing a wing as defined in claim 68, wherein:

one spar is located on said wing panel at one point using a coordination hole common to said one spar and said wing panel and is located angularly on said wing panel using another reference coordination fixture;

another spar is located on said wing panel by registry of another coordination hole common to said other spar and said wing panel, and is located angularly on said wing panel using a rib fastened between said spars to determine the spacing between said spars at a position along said spars remote from said coordination holes.

72. A method of manufacturing a wing as defined in claim 68, further comprising:

placing rib-to-spar critical coordination features in a plurality of in-spar ribs and in said spars using numerically controlled machine tools running on programs incorporating digital wing product definition from an engineering data authority, said ribs being accurately located in a predetermined position specified by said digital wing product definition relative to said wing spars when said rib-to-spar critical features in said ribs and said wing spars are positioned in a predetermined relation to each other.

73. A method of assembling a wing in accordance with a digital engineering product definition of said wing and within tolerances specified in said definition, comprising:

machining coordination features in major wing components, including a wing spar, a plurality of wing ribs, and a wing skin, using a numerically controlled machine tool running on a wing part program incorporating said digital wing product definition from an ultimate engineering data authority, said coordination features being accurately located in predetermined positions on said components specified by said digital wing product definition such that said components are positioned at positions specified by said digital wing product definition relative to each

other when corresponding ones of said coordination features are aligned with each other;

supporting a first wing skin in a horizontal orientation on a contoured fixture; and

locating the other of said components relative to said first wing skin in a configuration determined by said coordination features to produce a wing in accordance with said digital engineering product definition of said wing and within tolerances specified in said definition.

74. A method of assembling a wing as defined in claim 73, wherein:

probing reference surfaces on said wing panel after positioning said wing skin on said fixture with a coordinate measuring system to obtain accurate position data for said wing panel on said fixture; and

normalizing said wing part program to coincide with said accurate position of said wing panel on said fixture.

75. A method of assembling a wing as defined in claim 74, wherein:

said reference features include said coordination features in said wing skin.

76. A method of assembling a wing as defined in claim 73, further comprising:

checking the accuracy of said machine tool by probing a monument of known dimensions and location with a probe carried by said machine tool to compare the predicted dimensions and location of said monument with the dimensions and location as actually measured by said machine tool.

77. A determinantly assembled airplane wingbox, comprising:

at least two wing spars 34, 36 extending generally parallel to each other and separated chord-wise between upper 30 and lower 32 wing panels, each of said wing spars having an elongated upright web with upper and lower 144 flanges, said flanges each having installation coordination features machined therein;

said wing spar flanges fastened to said upper and lower wing panels at said certain positions thereon and within engineering tolerances

specified by a digital wing product definition established by an ultimate engineering authority for said wing design, said installation coordination features in said flanges accurately locating said spars within said engineering tolerances relative to said wing panels by registration of said coordination features in said spar flanges with corresponding coordination features in said wing panels;

said wing panel coordination features machined therein using a cutting bit in a machine tool under control of a controller programmed with a program incorporating data from said digital wing product definition, said digital wing product definition specifying locations of said wing panel coordination features in said wing panel for positioning said wing spars at said certain positions relative to said wing panels when said wing panel coordination features are in registry with corresponding coordination features in said spar flanges.

78. A determinantly assembled airplane wingbox as defined in claim 77, wherein:

said coordination features in said spar flanges include at least one coordination hole drilled adjacent one end of said spar, and said coordination features in said wing panels include corresponding coordination holes drilled in said wing panels by a drill bit in said machine tool.

79. A determinantly assembled airplane wingbox as defined in claim 78, wherein:

said coordination features in said spar flanges include an edge surface on said flanges extending alongside and in spaced relationship to edge surfaces of said wing panels, which constitute corresponding coordination features on said wing panels.

80. A determinantly assembled airplane wingbox as defined in claim 78, further comprising:

in-spar ribs 38 fastened at opposite ends thereof between said wing spars to rib posts 204 attached to said spars;

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said in-spar ribs having upper and lower flanges, said upper and lower flanges attached intermediate opposite ends thereof to said wing panels.

81. A determinantly assembled airplane wingbox as defined in claim 80, wherein:

said in-spar ribs are attached to said wing panels at preestablished positions by fasteners extending through fastener holes drilled through said upper and lower flanges of said in-spar ribs and through said wing panel, said fastener holes coinciding with coordination holes predrilled through said upper and lower flanges of said in-spar ribs and said wing panels and aligned with one another to position said ribs relative to said wing panel at said preestablished positions;

said preestablished positions existing in a digital model of said wing residing in said digital wing product definition, said fastener holes drilled by a machine tool under control of said controller programmed with a program incorporating said digital wing product definition data that specifies locations of wing-panel-to-rib-flange fastener holes for securing said in-spar ribs to said wing panels at positions specified in said digital wing product definition and achieved in said wingbox when said coordination holes in said in-spar ribs are aligned with corresponding coordination holes in said wing panel.

82. A determinantly assembled airplane wingbox as defined in claim 81, wherein:

said wing panels include wing skins and attached stringers, said stringers extending span-wise of said wingbox and lying between said ribs and said wing skins;

said stringers and said ribs have thickened pad-ups at locations at which said ribs intersect said stringers, said coordination holes extending through said pad-ups;

whereby said coordination holes provide enhanced certainty that said rib and said stringer pad-ups will vertically align within tolerance, enabling a reduction in area and weight of said pad-ups compared to conventional wings.

83. A determinantly assembled airplane wingbox as defined in claim 80, wherein: 204

said rib posts are positioned on said spars at certain positions and temporarily fastened thereon by temporary fasteners extending through aligned coordination holes in said rib posts and corresponding coordination holes in said spar webs, said certain positions existing in a digital model of said wing residing in said digital wing product definition.

84. A determinantly assembled airplane wingbox as defined in claim 83, wherein:

said rib posts are attached to said spar webs at said certain positions by permanent fasteners extending through fastener holes in said rib posts and said web;

said fastener holes in said rib posts and said web are drilled by said machine tool and said permanent fasteners are inserted and secured while said rib posts are temporarily secured in said certain position by said temporary fasteners extending through said aligned coordination holes.

85. A determinantly assembled airplane wingbox as defined in claim 84, wherein:

said temporary fasteners are replaced by additional ones of said permanent fasteners after said rib posts are secured permanently in said certain position by said permanent fasteners;

whereby said rib posts are positioned on said spar web with a high degree of accuracy within tolerances established by said digital wing product definition.

86. A determinantly assembled airplane wingbox as defined in claim 83, wherein:

said coordination holes in said rib posts and said spar webs drilled by at least one machine tool under control of at least one controller programmed with a program incorporating said digital wing product definition data that specifies locations of said coordination holes in said rib posts and said spar webs for aligning and positioning said rib posts on said spar webs at said certain positions specified in said digital wing product definition and achieved in said wingbox when said coordination

holes in said rib posts are aligned with said corresponding coordination holes in said spar web.

87. A determinantly assembled airplane wingbox as defined in claim 77, further comprising: 130

a plurality of aileron hinge ribs attached to a rearmost one of said wing spars and projecting rearwardly therefrom;

said hinge ribs each having a distal end in which is mounted a hinge barrel, said hinge barrels being axially aligned with hinge barrels on other of said hinge ribs on an axis at a position and within engineering tolerances specified in said digital product definition;

said hinge ribs each having an attachment fitting fastened to said rearmost spar, said attachment fitting positioned on said rear spar by mounting said hinge barrel on a positioning pin accurately located in space to the rear of said rear spar at a position specified by said digital wing product definition as the desired position for said hinge bushing in a distal end of said aileron hinge rib, and fastening said attachment fitting to said spar web at a position on said web which results in minimal movement of said hinge barrel when said locating pin in removed.

Respectfully submitted,

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